ORANGES Evaluation Phase I Risk Assessment Report

Phase I of the US DOT sponsored Evaluation of the ORANGES Electronic Payment Systems Field Operational Test

US DOT/Volpe National
Transportation Systems Center

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(Revision 1)

Foreword

This document is the US DOT evaluation Risk Assessment report for Phase I of the ORANGES field operational test. This report was preceded by a series of working papers corresponding to each Phase I task, including:

- Evaluation Strategy and Plan – issued November 6, 2001
- Test Plans – issued January 20, 2003
- Statistical Analysis of Before Data – October 2, 2003

This document consolidates these working papers and incorporates an assessment of issues, risks, mitigation strategies and lessons learned looking forward to Phase II of the evaluation effort.

Revision 1 incorporates additional information received from the implementation team subsequent to the original version dated January 13, 2004.

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1 Introduction

This report describes the findings for Phase I of the US DOT-sponsored evaluation for the Orlando ORANGES multi-modal Field Operational Test (FOT), including:

- a background description of the ORANGES deployment;
- the Evaluation Strategy and Plan, which establish the evaluation goals, measures and test hypotheses;
- the detailed Test Plans, which develop the specific test procedures for each measure and test hypothesis;
- the process used for conducting discussion groups for the qualitative Test Plans;
- findings from the discussion groups;
- statistical analysis of results from the quantitative Test Plans; and
- an assessment of the risks and lessons learned from Phase I of the ORANGES FOT evaluation.

2 Background Description of the ORANGES Field Operational Test System

2.1 Participants and Management Structure

The ORANGES partnership has a three-tier management structure:

- **Public Sector Partners:** The Central Florida Regional Transportation Authority (doing business as LYNX), the Orlando-Orange County Expressway Authority (OOCEA) and the City of Orlando are the Public Agency Partners, with LYNX also serving as the Federal grantee and manager of the FOT. The following individuals have been the primary representatives for the Public Sector Partners on the evaluation team:
  - Doug Jamison, LYNX
  - David Wynne, OOCEA
  - Pamela Corbin, City of Orlando Parking Bureau

- **Private Sector Partners:** These private sector firms implemented the FOT system under contract, on behalf of the Public Partners. Post Buckley Schuh & Jernigan (PBSJ) is contracted to LYNX as their General ITS & APTS Consultant, with FOT responsibilities including program management, oversight and implementation support. Touch Technology International (TTI)[1] is the Lead Technical Partner responsible for system development and integration, implementing and operating the clearinghouse – contracted to LYNX. The other initial Technical Partners were Leapfrog Smart Products[2] and the University of Central Florida[3] (supporting development and implementation of the smart card applications). Other Technical Partners joined the implementation team later – AnswerSearch (cardholder recruitment), Alliance Data Systems (merchant acquiring services for credit card transaction processing) and E-Squared Engineering (customer service strategy and brochures). Additional services and equipment suppliers included Suntrust Bank (ACH transfers of settlement funds), Ascom Transport Systems (transit validators), EFKON (toll plaza readers and smart card accepting transponder equipment), Gemplus (dual interface smart cards) and McGann Parking Systems (parking garage readers). The following individuals were the initial primary representatives for the lead Private Partners on the evaluation team:
  - Don Erwin, PBSJ[4]
  - Janet Mendenhall, TTI
- **Affiliates:** Various other organizations might eventually become involved in business relationships with the partnership. However, there are no affiliates at this point. The core focus of the FOT will be on evaluating the ORANGES system. Affiliates may join later if the system is successful, which will perhaps require new software applications for the regional smart card.

[1] During the course of the deployment, TTI underwent a corporate restructuring. The organization that became responsible for the ORANGES effort is known as Transaction Systems International (TSI)

[2] In 2002, Leapfrog entered Chapter 11 bankruptcy protection and their work was reallocated to others in the implementation team.

[3] By the end of the implementation period, it was concluded that UCF had not contributed to the project and would no longer be listed as a partner.

[4] In 2002, this role was assumed was Tom Delaney.

2.2 Deployment Overview

The FOT has implemented a central payment and clearinghouse system using core technology from Touch Technology Inc. (TTI). Payment transactions completed at smart card readers operated by individual agencies are transmitted to the ORANGES clearinghouse for settlement to agency-owned revenue accounts. Smart card payment applications are both agency specific and cash-based, including pre-paid transit passes, and account- and card-based stored value. Card-based stored value, or electronic cash, is stored in a purse application on the card and accepted as a form of payment across all agencies. The long-term ORANGES plan involves Central Florida residents and tourists using the prepaid accounts for many purposes.

The FOT involves a limited deployment:

- Card base: The agencies plan to maintain 800-1200 smart cards in active use at all times during the test. A single card can be loaded with multiple payment applications, thus allowing the card to be accepted for payment across all agencies.
- Transit deployment: LYNX has equipped Links 13 and 15, which both connect post-secondary educational institutions with the downtown area.
- Toll deployment: The Orlando-Orange County Expressway Authority (OOCEA) is equipping selected lanes of the Holland East toll plaza on State Route 408 to accept the EFKON transponder with a smart card as well as installing smart card accepting validators in selected manual lanes. Smart card acceptance through transponders was deferred one or two months from the initial deployment. The Holland East plaza is a 14-lane facility. Lanes 1-7 operate westbound, lanes 9-14 operate eastbound, and lane 8 is reversible. This plaza accounts for approximately 20% of the revenue and transactions annually for OOCEA.
- Parking deployment: The City of Orlando Parking Bureau has equipped cashier booths in the Central Boulevard, Library and Market Street garages.
- Revaluing facilities: Each agency offers facilities for smart card issuance and revaluing. This includes points of sale at agency-operated customer service facilities, selected attended toll lanes and some locations operated by third parties (additional details on revaluing locations and payment methods accepted are provided below). Passes will continue to be sold only through LYNX facilities and transponders will continue to be only available through OOCEA facilities.

- The strategy of technology deployment was specifically designed to isolate the smart card payment system from the existing legacy systems where necessary in the operation at each agency. This strategy offered the least risk to existing operation and revenue management.

2.3 OOCEA

Rather than integrate the existing E-PASS Electronic Toll Collection (ETC) system with the smart card clearinghouse, the OOCEA opted to create a parallel ETC system in equipped lanes, using EFKON smart card accepting transponders and smart card readers.

Figure 1: Transponder that Accepts Smart Cards

Source: ORANGES Consortium

Smart Card Accepting Transponders

The OOCEA customer service center will distribute the EFKON smart card accepting transponders in addition to conventional transponders (see Figure 1). Customers will insert the smart card into the EFKON transponder to have their toll fees deducted from their ORANGES toll account held at the central clearinghouse. The toll account operation is similar to to the EPASS account currently offered by the OOCEA to its customers.

EFKON transponders use infrared communications with the laneside readers and communicate with EFKON controllers in the toll plaza. The EFKON system will be integrated with the clearinghouse, bypassing the existing ETC system. OOCEA customers receiving an EFKON transponder will continue to use their conventional transponder for non-equipped toll lanes. The conventional transponder is also read by the Holland East plaza equipment, which activates the "paid" laneside signal (the OOCEA account is also charged in the process, but this is reversed out when there was a corresponding payment from the ORANGES account).

Smart Card Validators

Selected manual lanes are also equipped with EFKON validators (see Figure 2), similar to those used for payments on the LYNX buses. The validators allow customers to pay tolls using electronic cash stored on the smart card by stopping and placing the smart card in proximity to the validator mounted in the lane. The smart card is an alternative to tossing coins into the automated coin machines in the unattended cash lanes. The EFKON lane controller has been integrated with the existing lane violation system.

Figure 2: Toll Lane Smart Card Validator

Source: ORANGES Consortium

Therefore, after the card is presented for payment, the completed payment will trigger a green light signaling the driver to proceed.

2.4 LYNX

Figure 3: Stand-Alone Transit Smart Card Validator

Source: ORANGES Consortium

All buses have registering fareboxes, which LYNX recently replaced with a new model. Integration of smart card readers into this new farebox model was not practical from both a schedule and budget standpoint for the FOT. The ORANGES partners opted for stand-alone validators from Ascom Transport Systems (see Figure 3) to stay within budget and schedule constraints. These are mounted beside the fareboxes but not integrated with them. The ORANGES card will be used as an alternative to cash fare payment and the LYNX paper transit pass.

2.5 City of Orlando Parking Bureau

Figure 4: Parking Garage Validator

Source: ORANGES Consortium

Selected garages accept the ORANGES card using a smart card reader that has been integrated into a free-standing housing by McGann Software Systems, which also supports both proximity and swipe card technology (see Figure 4). The ORANGES card will replace the need for the hourly parker to pick up an entry ticket to mark the duration of time in the garage, as well as, provide electronic cash for the payment upon exit. Instead, the smart card is presented to the McGann reader upon garage entry and exit for fee calculation. The cash value stored on the card is debited for payment upon calculation of the parking fee. The transaction data is transferred to the ORANGES clearinghouse after being consolidated by the Parking revenue management system. At the request of the Parking Bureau participation in the FOT was restricted to hourly/daily customers and did not include monthly parking patrons, who currently use a proximity card

2.6 Smart Card Issuance and Revaluing

Cards are initialized centrally, and distributed to the cardholders by mail. Cardholders use one of the revaluing points to add value to the electronic purse or to purchase a LYNX transit pass and load it onto the card. Replacement cards will still be initialized centrally and then distributed either by mail or through one of the revaluing locations.

Table 1 summarizes the available revaluing locations and the payment methods accepted at each:

Table 1. Revaluing Locations and Payment Methods Accepted

Agency	Revaluing Location	Payment Methods Accepted		
		Cash	Check	Credit Card
Parking Bureau	Central Boulevard Garage – Cashier Booth	✔	✔	
	Central Boulevard Garage – Payment Office	✔	✔	✔
	Market Garage – Cashier Booth	✔	✔	
	Library Garage – Cashier Booth	✔	✔	
LYNX	Downtown Bus Terminal – Sales Window	✔	✔	
	Valencia Community College East – Book Store	✔	✔	✔
	University of Central Florida – Student Union Ticket Office	✔		
OOCEA	Holland East Toll Plaza – Designated Staffed Lanes	✔		
	East Side Service Center	✔	✔	✔

Some automatic revaluing arrangements are also available:

- LYNX offers an automatic pass renewal service. Customers may register by providing a credit card number, which is used to automatically renew a pass five days prior to its expiration. The clearinghouse automatically requests a credit authorization on the registered account for the amount of the new transit pass. This pass renewal will be updated on the card when it is used at a LYNX validator as long as a positive authorization has been received on the purchase request. The original pass on the card continues to be used to expiration before the next purchased pass is used for fare payment. If a successful authorization cannot be obtained, the existing pass on the card will continue in use until it expires.
- OOCEA offers automatic toll account replenishment of funds via a registered credit card. As tolls are paid, funds are moved from the customer toll account to agency revenue. The clearinghouse automatically generates a credit card purchase request for $20 to replenish the account whenever the balance drops to $5 or less. If a successful credit card authorization cannot

be obtained, the transponder that has been issued will be hot-listed once existing funds are depleted to prevent further use until funds can be replenished.

Cardholder Participation Incentives

The agencies are offering several cardholder participation incentives:

- Cardholders receive a 15% discount on single ride, weekly and monthly LYNX fares (i.e., $1.06 instead of $1.25 for a single ride);
- Parking customers receive 50% off hourly and daily parking fees; and
- OOCEA customers receive a smart card with $5 preloaded, and a $20 check at the end of the 12-month trial if they have remained an active user throughout the FOT period. This incentive was discontinued after issuance of the initial 300 cards by OOCEA, as it was determined that many customers discontinued use of the smart card once the initial five dollars was used.

2.7 Clearinghouse

The primary role of a clearinghouse is to process all of the transactions in the payment system according to business rules established by the members and to settle funds among the participating agencies. Settlement is the creation of the accounting entries and this action is done daily by the system. Funds movement, however, is a separate action that occurs bi-monthly in the ORANGES project. This decision was made by the partners to reduce the cost of bank fees for ACH due to the limited scale of the field operational test (FOT).

In the ORANGES project, the clearinghouse also performs two important additional functions. It facilitates all transit pass purchases by credit card and all load processing to electronic cash stored on the card or to toll accounts. The ORANGES clearinghouse also plays a unique role for LYNX in this implementation by providing all software and revenue management processing of the smart card transactions performed for transit. This "front-end" role is not generally handled by a clearinghouse, but is instead typically done by a transit agency itself using software it has received from the hardware vendor. In ORANGES, Ascom Transport Services only provided the bus validator and collector hardware devices, but no operating software. Therefore, the clearinghouse system is performing both front-end and back-end processing for LYNX during this FOT.

In ORANGES, settlement processing is based upon the type of payment application, the owner of the application (including considering whether the application is shared among participants) and the issuer of the card. Settlement of payment applications can be very straightforward or more complex according to business rules. In the ORANGES project, there is only one transit agency, LYNX. Therefore, transit pass sales are only handled through LYNX or its contracted agents. All funds from transit pass sales are deposited by the clearinghouse into the LYNX revenue account.

The settlement of payments made with electronic cash requires the clearinghouse to know the issuer of the card and the owner of the reader where the payment was made. If, for example, a cardholder is issued a card from LYNX and loads $30 into the electronic purse on the card, these funds are held by LYNX in an account called a funds pool until the electronic cash is used for payment. If during a certain settlement period, the LYNX card were used to make $3 in toll payments at OOCEA and $1 in payments at parking garages, the clearinghouse would execute the settlement by transferring these amounts from the LYNX account to the bank (revenue) accounts of the other agencies. If the card were used to pay $1.06 for a bus ride, the clearinghouse would transfer funds from the LYNX funds pool to the LYNX revenue account. Additionally, if the LYNX cardholder makes the initial payment at a revaluing device operated by another agency, the funds will be initially placed in the account of the agency that receives the revaluing payment from the cardholder. However, the settlement process is used to transfer the funds to LYNX.

In the ORANGES project, the agencies were free to establish the accounting instructions that the clearinghouse should use in the settlement process. Both the OOCEA and the City of Orlando have chosen to use a single bank account for settlement, but to utilize reporting from the clearinghouse to make the appropriate internal account entries for revenue and for value held in the funds pool. LYNX has opted to maintain two separate bank accounts during this project. One bank account is for holding the funds pool that has not yet been used by the cardholders for purchases. The other is the LYNX revenue account for holding funds received for LYNX pass purchases and collected transit fares.

The various funds movements that are to occur in and out of each agency account with daily settlement are consolidated into net transfers through the use of a clearing account. Funds movement occurs every two weeks. Table 2 provides sample reconcilement information that summarizes the derivation of the net settlement payments.

Table 2. Sample Clearinghouse Settlement Activity

E-CASH ACTIVITY AND SOURCE

	LYNX		OOCEA		City Parking		Net To/From Funds Pool
LYNX	$ (1.00)	$ 36.50	$ (0.75)	$ -	$ -	$ -	$ 34.75
OOCEA	$ (0.75)	$ -	$ (341.79)	$ 780.05	$ (2.50)	$ -	$ 435.01
City	$ (3.00)	$ -	$ (26.25)	$ 50.00	$ (114.50)	$ 424.19	$ 330.44
	$ (4.75)	**$ 36.50**	**$ (368.79)**	**$ 830.05**	**$ (117.00)**	**$ 424.19**	**$ 800.20**

Accounts

LYNX Funds Pool	$ (1.00)	To LYNX Revenue for e-cash purchases
	$ (277.10)	To LYNX Revenue for pass purchases
	$ (0.75)	To OOCEA for purchases
	$ (278.85)	**Net to Clearing Account**
LYNX Revenue	$ 1.00	From LYNX FP for e-cash purchases
	$ 277.10	From LYNX FP for pass purchases
	$ 0.75	From OOCEA for purchases
	$ 3.00	From City for purchases
	$ 281.85	**Net from Clearing Account**
OOCEA	$ 0.75	From LYNX FP for purchases
	$ 26.25	From City for purchases
	$ (0.75)	To LYNX Revenue for purchases
	$ (2.50)	To City for purchases
	$ (50.00)	To City for loads
	$ (26.25)	**Net to Clearing Account**
City Parking	$ 2.50	From OOCEA for purchases
	$ 50.00	From OOCEA for Loads
	$ (3.00)	To LYNX Revenue for purchases
	$ (26.25)	To OOCEA for purchases
	$ 23.25	**Net from Clearing Account**
	$ (305.10)	**Total credits to Clearing Account**
	$ 305.10	**Total debits to Clearing Account**

2.8 Implementation Schedule

The FOT deployment used the following approach to system design and development:

- *Pilot I:* The test-bed version of the system, demonstrating the integration of all equipment and subsystems in a laboratory testing environment, was to have been developed during the initial 11 months (i.e., April 2001 through February 2002). This stage of development actually took place over the 26 months between April 2001 and May 2003. This test-bed system created a prototype of the revenue service pilot in a laboratory-testing environment.
- *Pilot II:* The limited FOT field deployment was to have been completed, brought into revenue service and fully tested between months 12 – 18 (i.e., March 2002 through September 2002). Full FOT implementation was scheduled to overlap with the more limited Pilot II effort – from June 2002

through February 2003. The full FOT deployment was actually implemented from the start, with no intermediate limited deployment. So, the development from Pilot I through to full FOT deployment was to have spanned over the 12 months from March 2002 through February 2003. The Pilot II stage of development was initiated prior to the completion of Pilot I in May 2003, and brought into revenue service by August 2003. At that time, some functionality was not initially in place – in particular the toll accounts processing needed to support the smart card accepting transponders.

Overall, full field deployment was to have been completed over the 23 months between April 2001 and February 2003. This effort was actually completed (with the exception of deferred functionality such as the toll accounts processing for smart card accepting transponders) over the 29 months between April 2001 and August 2003. Much more time than anticipated was spent on addressing various design and resource availability issues, stretching the time to the completion of the Pilot I stage from 11 months to 26 months. During the latter stages of Pilot, development of Pilot II was underway – as a result only 3 months passed after the completion of the Pilot I stage until the system was brought into revenue service.

3 Evaluation Strategy and Plan

3.1 US DOT Evaluation Process

As part of the ITS program, US DOT requires that each FOT have an independent evaluator. This national evaluation is a supplementary effort to the locally funded and managed FOT self-evaluation. The national evaluation is separately funded and has independent goals, objectives, schedule and deliverables. The US DOT evaluations also provide useful feedback to the local FOT participants as well as other interested transportation stakeholders.

For further details, please refer to the TEA-21 Evaluation Guidelines, www.its.dot.gov/eval/ResourceGuide (originally published in the Federal Register). A brief overview of some material from the Guidelines is provided below for ready reference – together with the approach being used in the ORANGES evaluation:

- US DOT program assessment has a dual focus:
  - **Outputs:** The evaluation documents *what was done* in the FOT (e.g., systems built, the capabilities provided, institutional arrangements). The

background description of the ORANGES system provided in Section 2 of this report is the initial step in developing this type of documentation.

- **Outcomes:** The evaluation documents *what was achieved* through the FOT, relative to a set of goals and measures established in collaboration with the local participants early in the effort. Goals and measures have been developed by consensus for the ORANGES evaluation – as discussed in the Section 4 of this report.

- The federal Evaluation Guidelines define a common process for both the US DOT and local evaluations:
  - **Establish the Evaluation Team:** Evaluation team members should include participants from all local FOT participants (public and private sector partners) as well as representatives from the US DOT evaluation team[5]. The ORANGES evaluation team includes the core public agency partners as well as the lead private sector partners.
  - **Develop the Evaluation Strategy and Plan:** The evaluation team establishes the goals and measures that will be the focus of the evaluation. Each goal with a quantifiable measure is framed as a testable hypothesis – involving a statement about a potential benefit the FOT is expected to provide. The need to support certain goals with a qualitative assessment is also considered. In these cases, measurement involves monitoring the evolution of opinion for various groups of FOT participants (e.g., customers and/or employees) through discussion groups without any particular hypothesis.
  - **Develop Test Plans:** For each testable hypothesis and qualitative assessment, a plan is defined for gathering data on the associated measure. This includes defining desired opportunities to gather data for the before vs. after – and/or test vs. control – dimensions.
  - **Data Collection and Analysis:** The quantitative and qualitative data required by the test plans is collected – and used for qualitative assessments and comparison with the testable hypotheses. The role of the initial data collection is to gather "baseline" data about initial conditions before the FOT system is in place. Only this "baseline" data can be collected in Phase I – the remainder of the data collection will occur after the FOT system has been implemented.

[5] The US DOT Evaluation Team for the ORANGES Evaluation was led by the Federal Transit Administration and the Volpe National Transportation Systems Center, with technical support from TranSystems.

- **Document the Evaluation:** The strategy, plans, results, conclusions and recommendations are combined into an Evaluation Final Report (this document).

3.2 Developing Consensus on the Evaluation Goals and Measures

The process for developing a consensus on an initial set of evaluation goals and measures was completed in collaboration with the ORANGES partners – and included the following steps:

- Generating a list of potential goals and measures based on input from the partners. These were discussed with the partners, including how data could be collected.
- Soliciting input from each partner independently on relative priority for the goals.
- Developing consensus with the partners on the initial set of evaluation goals and measures.

The starting point for this consensus building effort was a set of goals and measures proposed by the USDOT evaluation team. These were developed based on the priority input received from the partners as well as the following additional considerations:

- Consistency with goals of the federal ITS program.[6]
- A clearly associated benefit and measure.
- A *feasible and reasonable data collection* method for the measure, consistent with the scale and duration of the FOT.

Feasible and reasonable data collection generally corresponds to measures for which either:

- Quantitative data can be provided by the operating agencies (or derived from data that can be provided).
- Qualitative input can be gathered from discussion groups whose participation can be arranged by the operating agencies.

[6] The following National ITS goals are cited in the Guidelines: (1) traveler safety; (2) traveler mobility; (3) transportation system efficiency; (4) productivity of transportation providers; (5) conservation of energy and protection of the environment; and (6) others as may be appropriate to unique features of the project.

3.3 Evaluation Goals, Measures and Test Hypotheses

Tables 3 and 4 identify the set of quantitative and qualitative goals and measures initially established for the evaluation and were developed through the consensus-building process. The tables also list the fundamental test hypothesis for each quantitative goal and measure. This initial consensus creates the basis to develop test plans and investigate sources for the baseline data collection effort. Nonetheless, this initial set of evaluation goals and measures may need to be amended:

- As the design of the FOT is finalized.
- If issues emerge with ensuring feasible and reasonable data collection.

Table 3: Quantitative Evaluation Goals/Measures and Test Hypotheses

FOT Evaluation Goal	Measure	Test Hypothesis
1. Increase parking revenue	• $	• Revenue will increase from parking payment equipment that accepts smart cards, due to increased equipment availability and improved customer convenience. The degree of revenue increase will vary for different types of parking equipment.
2. Increase transponder market penetration	• Number of smart card users that newly acquire a transponder	• Of the smart card users, some will choose to newly acquire a transponder
3. Reduce transaction times	• Average transaction times	• Smart card transactions will be quicker than cash payment, so average time will reduce if there is a shift from cash to smart card.
4. Increase prepaid revenue share	• % revenue prepaid	• The % of revenue that is prepaid will increase for equipment that accepts smart cards
5. Reduce monthly pass distribution costs	• Procurement, inventory, delivery, commissions for any conventional passes made available on smart cards	• The number of conventional passes being distributed will decrease, thus reducing distribution costs

6. Increase automated payment equipment uptime	• % equipment availability	• The decreased use of cash will improve equipment reliability
7. Cardholders use the joint account[7]	• Card use profiles • Average prepaid balance • Modal use profile	• Customers that activate joint transportation accounts will maintain a prepaid balance and use the card frequently. Multimodal use by individual cardholders will most often involve tolls and parking.

Table 4: Qualitative Goals/Measures and Test Hypotheses

FOT Evaluation Goal	Measure
8. Understand customer perceptions • General benefits • Ease of use • Convenience of revaluing	• Customer feedback
9. Understand operations/maintenance staff perceptions, including: • General benefits • Reduced payment disputes • Reduced transfer abuse • Ease of customer use • Maintenance	• Operations/maintenance staff feedback
10. Understand planning/management staff perceptions, including: • General benefits • More comprehensive data collection	• Planning/management staff feedback
11. Understand interagency perceptions, including: • General institutional issues • Interagency collaboration	• Partnership feedback

4 Test Plans for Quantitative Goals

This set of evaluation goals involves numerical measures and initial test hypotheses. In assessing any changes observed, it will be important to consider the limited scale of deployment. Many of the quantitative goals and measures involve potential changes in payment behavior (e.g., using a new payment method, willingness to make prepayments). Such changes in behavior might increase with a more comprehensive deployment and after the system has been in place longer.

[7] At this point in the design process for FOT implementation, it is understood that the joint account will only involve the ability to use one or more different types of smart card with smart card readers installed at transit, parking and toll facilities. Joint account is not expected to involve any use of the same account for both smart cards and toll transponders.

Tables 5 and 6 summarize the required before and after data collection, as detailed in the remainder of this section.

4.1 Quantitative Goal 1 – Gather Clearinghouse Performance Measures

The clearinghouse operator will provide measures that characterize the clearinghouse operational performance (e.g., processing time required for transaction batches, communications error rates) as well as identify the specific measures. There is no test hypothesis for this goal. During after testing, the evaluators will complete a statistical assessment.

Table 5: Summary of Before Data Collection

Quantitative Goals	Facility Type			
	Clearinghouse	Buses	Garages	Toll Lanes
Goal 1 – Clearinghouse Performance Measures				
Goal 2 – Acceptance Test Results				
Goal 3 – Demonstrate Performance for New Transponders				
Goal 4 – Transaction Times		✔	✔	
Goal 5 – Prepaid Revenue Share		✔	✔	
Goal 6 – Automated Equipment Uptime		✔		✔
Goal 7 – Joint Account Use				
Goal 8 – Current Pass Distribution and Permit Billing Costs		✔	✔	
Goal 9 – Current Processing Cost per Cash Transaction		✔	✔	✔

Table 6: Summary of After Data Collection

Quantitative Goals	Facility Type			
	Clearinghouse	Buses	Garages	Toll Lanes
Goal 1 – Clearinghouse Performance Measures	✔			
Goal 2 – Acceptance Test Results	✔	✔	✔	✔
Goal 3 – Demonstrate Performance for New Transponders				✔
Goal 4 – Transaction Times		✔	✔	
Goal 5 – Prepaid Revenue Share		✔	✔	

Goal 6 – Automated Equipment Uptime		✔		✔
Goal 7 – Joint Account Use	✔			
Goal 8 – Current Pass Distribution and Permit Billing Costs				
Goal 9 – Current Processing Cost per Cash Transaction				

4.2 Quantitative Goal 2 – Gather System Acceptance Test Results

The program manager will provide results from acceptance testing completed before the system is brought into revenue service. There is no specific measure or test hypothesis, but the acceptance testing results will provide an important baseline for the operational characteristics of the system.

4.3 Quantitative Goal 3 – Demonstrate Reliable Performance for Smart Card Accepting Transponders

The EFKON smart card accepting transponder is unproven in North America, and uses an infrared interface (also unproven in North America). The goal is to demonstrate reliable equipment operation during the operational test that does not adversely impact customer reaction to the ORANGES card.

Measure

- Difference between the numbers of monthly transactions for smart card accepting and conventional transponders.

Test Hypothesis

- Using a smart card accepting transponder instead of a conventional transponder will not reduce the number of transponder-based transactions.

If there were significant operational problems with the smart card accepting transponder or the interface, customers might divert some transactions to cash. The EFKON equipment is established in Europe and Asia, but this must be established for the FOT.

Modes Involved

- Toll

Types of Data Comparisons

- Test and control

  The test will measure the average number of monthly transponder transactions by smart card transponder users. The control test will measure

the average number of monthly transponder transactions by conventional transponder users. These monthly totals will be examined throughout the operational test period for any reductions in use over time. Reductions for the smart card accepting transponders that reflect similar reductions in use of conventional transponders would still support the test hypothesis.

Data Needed

- Average number of monthly transactions for a group of smart card accepting transponders and a comparable group of conventional transponders.

Data Collection Methods

The clearinghouse will provide the number of toll transactions for smart card transponders. The existing E-Pass ETC system must provide the number of transactions completed by selected conventional transponders. Transponders of both types must have comparable travel patterns (e.g., commuters who average two toll transactions per weekday).

4.4 Quantitative Goal 4 – Reduce Transaction Times

Reducing average transaction times is important for all three modes and could translate directly into reduced queuing and bus dwell times. This quantitative goal does not apply to tolls, since the percentage paying by transponder or smart card will not noticeably increase within the high volume of daily plaza transactions.

Measure

- Average payment transaction duration, for each mode and type of equipment.

Test Hypothesis

- Prepaid payment transactions will be quicker than cash payment, so the average duration will decrease if the % prepaid increases.

Modes Involved

- Parking garages
- Transit

Types of Data Comparisons

- Before and after

Data Needed

- For each equipped parking garage exit or bus
  - Average transaction duration

Data Collection Methods

The basic approach for each equipped device will be to measure throughput with continuous demand. Average transaction time is the inverse of throughput.

The transit method will use the LYNX Automatic Passenger Counters (APC) vehicles. APC counts passengers that board and alight at each stop, and bus dwell time. Dwell time divided by the number boarding will provide the average transaction time for that stop. LYNX will identify any stops where alighting volume governs dwell time (i.e., which would cause high average transaction times).

For parking garages, transaction records for the cashier station plus those for the validators from the clearinghouse will provide the total. If the Parking Bureau cannot identify periods of continuous demand without field observation, it may be easiest for their staff to visually count the transactions.

4.5 Quantitative Goal 5 – Increase Prepaid Revenue Share

The agencies wish to (1) reduce cash handling costs and (2) increase the "float" investment revenue earned from holding prepaid revenue. However, changes in cash handling costs and float revenue are not expected due to the limited scale of deployment. Prepaid revenue share was selected as a surrogate quantitative goal that may be measurable for equipped facilities. It is necessary to determine whether some of the ORANGES card usage is displaced from other prepaid payment methods rather than from cash. This goal does not apply to tolls, since the percentage paying by transponder will not noticeably increase within the high volume of daily plaza transactions.

Measure

- % of transactions that use a prepaid revenue payment method

Test Hypothesis

- % prepaid transactions will increase for equipment accepting the ORANGES card.

Modes Involved

- Parking
- Transit

Types of Data Comparisons

- Before and after.

Data Needed

- For each payment device equipped for smart card acceptance
  - % transactions paid with cash
  - % transactions paid with the ORANGES card
  - % transactions paid with other non-cash methods

Data Collection Methods

Each agency will gather data from its revenue systems. These systems include the transaction data from parking garages, the revenue systems at LYNX garages and clearinghouse data.

4.6 Quantitative Goal 6 – Increase Automated Payment Equipment Uptime

Cash accepting equipment can suffer more downtime as the cash volume increases. This applies more to automated devices than to attended locations. By displacing cash use, the ORANGES card should reduce downtime. This would reduce maintenance costs and revenue loss (i.e., at unattended devices where revenue cannot be collected while the device is down).

Measure

- % operating hours with cash processing available (coins for toll machines; coins and bills for fareboxes)

Test Hypothesis

- The frequency and severity of planned and unplanned maintenance for unattended devices relates to the cash processed. Cash processing availability should increase as % prepaid increases.

Modes Involved

- Tolls – for automatic coin machines
- Transit – for fareboxes

Types of Data Comparisons

- Before and after

Data Needed

- For each equipped and control device
  - Daily cash revenue
  - % of operating hours each day with cash processing available

"Daily cash revenue" and the data collected for Goal 6 (i.e., % paid by cash, ORANGES card and other non-cash methods) will be used to take into account any differences in the level of cash acceptance between the before and after – and test and control – availability data.

Data Collection Methods

Data will be gathered by agencies from maintenance records.

LYNX maintenance tracks each incident and whether the cash processing is taken out of revenue service. They will provide the average number of failures per month and the duration out of revenue service.

OOCEA data may be more limited. Coin machines are maintained under a fixed price contract and the actual maintenance may not be available. The ETC system data indicates when each lane was out of service, but this may not indicate whether an outage is due to a coin machine failure.

If needed due to variations in repair frequency and severity, before and after data collection should be completed in the same season.

4.7 Quantitative Goal 7 – Cardholders Use the Joint Account

Agencies hope ORANGES cards are used to travel between modes and store high prepayments. This quantitative goal measures how and where cards are used (i.e., rather than the effects of the card use, with other quantitative goals).

Measures

- Cumulative probability distributions for transaction frequency, over the cardholders population, segregated between payment and revaluing transactions as well as by mode
- Cumulative probability distributions for transaction value, over the transactions population, segregated between payment and revaluing transactions as well as by mode
- Average stored value balance, for each card, segregated on the basis of card use frequency
- Percentage breakdown of the cardholder population, between cards used for one mode, for mode pairs or for all three modes.

Test Hypothesis

- Most cardholders will maintain a prepaid balance and use the card regularly. Some may use the card alternately for transit and tolls, some for downtown parking and toll payment. Use for transit and parking is not expected to be common for this operational test because the selected transit routes do not serve park and ride facilities.

Modes Involved

- Parking
- Tolls
- Transit.

Types of Data Comparisons

- Test only

  These measures involve the specifics for card use, so there are no before or control tests.

Data Needed

- Individual transaction values and dates, by cardholder, for each payment and revaluing device
- The stored value balance after each transaction

Data Collection Methods

The clearinghouse will gather the data from their transaction and balance databases.

4.8 Quantitative Goal 8 – Characterize Current Pass Distribution and Permit Billing Costs

LYNX uses prepaid fares extensively, issuing paper and magnetic stripe passes distributed through four sales outlets and by mail order. For the FOT, LYNX passes will be renewed directly on the smart card at sales outlets or revaluing locations. Sales locations will need fewer paper passes, which should provide savings.

The ORANGES card can also replace the monthly "proximity" permit for garage parking. Permit holders are billed monthly. Although not provided in the initial deployment, the system could in the future potentially be modified so that a permit on the card could be automatically renewed and billed to a pre-registered credit card.

However, any reduction in passes distributed will be limited during the test (and permits will still be billed using conventional methods). Characterizing current costs for pass distribution and permit billing will indicate potential cost savings if future deployment achieves bigger reductions.

This does not apply for tolls, which already use a transponder and autoload.

Measure

- Costs for distributing (e.g., procurement, inventory, delivery and commissions) conventional weekly and monthly passes.
- Costs for monthly billing of garage permits.

Test Hypothesis

- None. The limited test scale is not expected to have much impact on these costs.

Modes Involved

- Transit
- Parking garages

Types of Data Comparisons

- Before only

Data Needed

- Number of weekly and monthly passes distributed per month.
- Number of garage "proximity" permits billed per month.
- Monthly cost for distributing passes. Detail the specific cost categories included.
- Monthly cost for billing garage permits. Detail the specific cost categories included.

Data Collection Methods

LYNX will provide monthly costs for distributing passes to sales outlets. City Parking will provide monthly costs for billing garage permits. This will include the types of costs to assist in interpreting the findings.

4.9 Quantitative Goal 9 – Characterize Current Processing Cost per Cash Transaction

ORANGES cards should decrease cash processing costs for transit, parking and tolls. However, many types of cash processing savings may not be achieved until card use is widespread. The limited use of smart cards in the test may not achieve a cost savings in this area.

Characterizing current cash processing costs will indicate potential cost savings if future deployment achieves bigger reductions.

Measure

- Costs for processing cash, for each mode.

Test Hypothesis

- None. The limited test scale is not expected to have much impact on these costs.

Modes Involved

- Transit
- Tolls
- Parking garages

Types of Data Comparisons

- Before only

Data Needed

- Monthly costs for processing cash, by mode.
- Dollar value of cash processed monthly, by mode.

Data Collection Methods

Each agency will provide the monthly cost for cash processing. This will include the types of costs to assist in interpreting the findings.

5 Test Plans for Qualitative Goals

The qualitative goals use discussion groups – focusing on the perceptions of various user categories. Discussion groups are exploratory, so test hypotheses were not developed. Hypotheses may be identified based on before data, depending on the views expressed.

5.1 Qualitative Goals 10 to 13 – Understand Perceptions of System Users (By User Category)

Measure

- Evolution of user perceptions expressed in discussion groups.

Modes Involved

- Parking
- Tolls
- Transit

Types of Data Comparisons

- Before and after

  Discussion group participants should be users of the test system.

Data Needed

- Customers
  - General benefits
  - Ease of use
  - Convenience of revaluing
- Operations and maintenance staff
  - General benefits
  - Reduced payment disputes
  - Reduced transfer abuse
  - Ease of customer use
  - Maintenance
  - Training
- Planning and management staff
  - General benefits
  - More comprehensive data collection
- Partners
  - General institutional issues
  - Inter-partner collaboration issues

6 Discussion Group Process

6.1 Overview and Organization

The Evaluation Test Plans document identifies the data collection requirements for the set of goals and measures identified in collaboration with the Implementation Team. As part of this data collection effort, qualitative data is to be collected via three discussion groups. Discussion groups will be

comprised of 10-15 individuals. The discussion groups will represent: (1) customers and cardholders; (2) operations and maintenance staff; and (3) management and planning staff. The purpose of the discussion groups is to elicit information, opinions and preferences regarding the use of the ORANGES smart card.

The Implementation Team will arrange the logistics for conducting these discussion groups (e.g., facility, refreshments, incentive payment). The Evaluation Team will also play a direct role in helping the implementation team with these arrangements, to help ensure its goals are met. The discussion groups will be conducted at facilities provided by the agencies. This will likely be a meeting room at OOCEA, but could be elsewhere if the agencies choose. The prerequisites for the facilities are that they: (1) allow for providing understandable directions to attendees; (2) allow for evening access given the location and building security; (3) have adequate visitor parking nearby; (4) have enough space; and (5) have washroom facilities. If suitable meeting rooms at agency-operated locations are not available, the Evaluation Team can assist in referring the Implementation Team to the operators of suitable rented space (e.g., hotel meeting rooms).

Each group will have a facilitator to guide the discussion. The facilitators will be representatives from the Evaluation Team. The discussion group facilitator will elicit responses from group participants using open-ended style questions and polling.

Discussion groups will focus on and collect information about the following general topics:

- Cardholders
  - General benefits
  - Ease of use
  - Convenience of revaluing
- Operations and maintenance staff
  - General benefits
  - Reduced payment disputes
  - Reduced transfer abuse
  - Ease of customer use
  - Ease of operator use

  - Maintenance
  - Training
- Planning and management staff
  - General benefits
  - More comprehensive data collection

6.2 Selecting Discussion Group Members

Discussion group participant selection will involve a collaborative effort by the Implementation Team and the US DOT Evaluation Team.

General Selection Criteria

Recruited customers (cardholders) should represent the three smart card uses (transit, tolls and parking):

- **For toll customers**, the primary selection criteria will be a regular travel pattern that involves the toll plaza included in the test (i.e., Holland).
- **For parking customers**, the primary criteria will be regular use of one of three downtown parking garages included in the test (i.e., CBG, Library or Market).
- **For transit customers**, the primary criteria will be regular riders on Links (routes) included in the test (i.e., Link 13 or 15). There will also be an attempt to include those that use facilities from two or more of the agencies.

Pre-screening criteria for cardholders

Each of the three implementing agencies took responsibility for recruiting a number of the cardholders. As part of this effort, the Implementation Team gathered pre-screening information to assist with selecting participants for the discussion groups. Appendix A includes the discussion group pre-screening questions used for the LYNX recruitment effort.

The US DOT Evaluation Team reviewed cardholder characteristics as gathered by the implementing agencies through the their recruitment efforts, and clustered them into recruitment subgroups (e.g., recruit 5 from toll users, 5 from LYNX Link 13 and 15 riders, and 5 parking customers.). The Implementation Team used these subgroups to recruit cardholder discussion

group participants, using phone, mail or email to solicit potential cardholder discussion group participants.

Employee Selection Process:

These participants were selected by the agencies prior to FOT implementation. The Evaluation Team recommended that the agencies avoid relying entirely on voluntary participation, and assure participating employees are separated from their supervisors (there is a benefit to having both those who wish to speak and those more reluctant to speak involved in this process). The agencies submitted their set of selected employee participants to the Evaluation Team in advance, to assist in preparing for the discussion groups.

6.3 Discussion Group Conduct

The FOT included the conduct of facilitated and focused discussion groups before the operational test period, and it is intended that these be repeated near the end of the demonstration period for after testing. The before test sessions were held shortly after the start of the initial pilot FOT. The after sessions should be held within a month after the completion of the FOT.

The discussion groups lasted about two hours and were conducted in a comfortable setting. This provided adequate time for dialog among the participants and the facilitator (Randy Farwell of TranSystems) in response to a set of open-ended questions. The Implementation Team identified appropriate venues for the sessions (a conference room at OOCEA headquarters), with assistance from the Evaluation Team.

The general approach to the discussion was to combine open-ended questions with "polling" type questions where the participants were asked to choose or rank from several presented or group generated options. The discussion group scripts are included in Appendix A. The general role of the facilitator was simply to ensure that the discussion kept moving and that some participants were not heard from too disproportionately compared to others.

One of the challenges with the groups was to avoid having much time consumed with generalized complaints that were unrelated to the operational test. This was done in a way that recognized that allowing a limited amount of such "venting" can contribute to the participants general openness in responding to the questions.

Cardholder Group

Recruited cardholders were taken through a structured group discussion that drew out their perceptions about key aspects of the program. The cardholder discussion group focused on matters involving the following:

- Convenience of use
- Trust and comfort level of use
- Reporting, informational needs (statements, etc.)
- Discounts and incentives
- Attitudinal perceptions regarding investment of effort by agency as compared with focusing on core functions (does a multipurpose smart card have benefits to users and is this a worthwhile effort of the agencies?)

The Implementation Team provided a stipend of $50 to customer group/cardholder participants.

Employee Groups

Employee groups included representatives from transit, tolls and parking agencies. The employee information collected included:

- Gender and age (within set age ranges)
- Employer
- Employee work function (planning, management, operations or maintenance category, and their specific role in the organization)

Employee discussion groups focused on matters involving the following:

- Perceived convenience of use to customer
- Convenience of use to agency
- Perceived trust and comfort level of use by customer
- Trust and comfort level of use by the employee (are there concerns that employers will monitoring employees, for example)
- Trust and comfort level of use by the agency (are there management, concerns such as privacy, liability, monitoring employees, etc.)

- Reporting and informational needs (data collection, reports, statements, data storage, record-keeping, market research, marketing, etc.)
- Discounts and incentives (planning, management, marketing, record-keeping)
- Reliability and quality control (operations, maintenance, planning, management issues)
- Attitudinal perceptions regarding investment of effort by agency as compared with focusing on core functions (does a multipurpose smart card have benefits to users and is this a worthwhile effort of the agencies?)

6.4 Discussion Group Scripts

The conduct of the discussion groups followed a series of open-ended questions and group polling to elicit views, opinions, attitudes and suggestions about the FOT. Discussion group scripts are presented below for each of the groups. Although these scripts directed the facilitator in leading the discussion groups, they were not intended to be followed verbatim but were rather used as a map for the facilitator. The facilitator used his/her discretion to follow relevant discussion trails as they became clear.

Cardholder Group

Groups were instructed to arrive 15 minutes prior to the start of the discussion group to sign in to assure the discussion group session starts on time. Group members were invited to enter the venue and have a seat as they completed the sign-in process. Refreshments were available and they were invited to partake.

Once the group was present, the facilitator introduced himself and stated his role. This was to ask questions of the group, facilitate expression of opinions, record ideas on a flipchart and allow all to have a chance to speak.

Employee Groups

Discussion group participants were instructed to arrive a few minutes prior to discussion group and sign in noting name, organization, and position.

Discussion group participants were invited to enter the venue and have a seat as they completed the sign-in process. Refreshments were available and they were invited to partake.

Once the discussion group participants were present, the facilitator introduced himself and stated his role in this discussion group. This was to ask questions

of the group, facilitate expression of opinions and allow all to have a chance to speak.

7 "Before" Data Analysis for Quantitative Goals

For each goal requiring before data collection, the document reiterates the selected measure and (where applicable) the test hypothesis, followed by a discussion by mode about the data collected and the analysis. The data collection discussion identifies the type of data, method of collection, time periods and facilities.

The data collected for most of the measures is only a sample, so statistical analysis was performed. This is important because unforeseen circumstances can cause the variations in data. For example, the duration for a set of boarding transactions varied due to factors such as how long people take to pay with cash or whether the driver is asked for directions. The estimates for pass distribution, permit billing and cash processing costs are not samples and thus did not need statistical analysis.

First, the average and standard deviation was calculated. Using the standard deviation (a measure of how widely dispersed the sample observations may be) and the sample size, a statistical inference statement was developed. This was of the form, "With a 95% level of confidence, the overall population average for this sample is expected to lie within the following range around the sample average".

This expected range is known as the confidence interval, and can be expressed as a precision percentage. For example, a range from 75 to 125 around an average of 100 can be expressed as +/- 25% precision. The statistical relationship for the precision percentage (for the 95% confidence level) can be expressed with the following formula:

- $P = ((1.96*\sigma)/\sqrt{N})/X$

  Where:
  P = Precision percentage
  X = Average
  σ = Standard Deviation
  N = Sample Size

7.1 Quantitative Goal 4 – Reduce Transaction Times

Reducing average transaction times is important for all three modes and can translate directly into reduced queuing and bus dwell times. This quantitative

goal has not been applied to tolls for the evaluation, since the percentage paying by transponder or smart card will not noticeably increase within the high volume of daily plaza transactions.

Measure

- Average payment transaction duration, for each mode and type of equipment.

Test Hypothesis

- Prepaid payment transactions will be quicker than cash payment, so the average duration will decrease if the % prepaid increases.

Data Collection and Analysis

Parking

At each of the three equipped parking garages (Central Boulevard, Library and Market), a Parking Bureau observer recorded the duration for a sample of payment transactions at the cashier booth. The transaction time was the length of time the vehicle was stopped at the booth.

Table 7 summarizes the sample size, average, standard deviation, and precision percentage for each of these samples. The confidence intervals on the average for each garage are similar enough that it seems reasonable to combine the garages together into a single large sample. For all garages together, we make the following statistical statement:

- Three garages combined: At the 95% confidence level, the average transaction time is expected to be 23.3 s +/- 5% (i.e., between 22.1 and 24.5 seconds, 95% of the time).

Transit

On buses for each of the two equipped LYNX bus routes (Links 13 and 15), the Automatic Passenger Counting (APC) equipment was used to gather data during selected weeks when these buses were in use on these routes (only a subset of the LYNX bus fleet is APC-equipped). The APC equipment records at each stop the number of passengers that boarded and alighted as well as the duration the doors were open.

Several data filtering steps were taken to help construct samples where the duration the doors were open could be divided by the number of boarding

passengers at that stop to best represent the average transaction time per boarding passenger at that stop:

- LYNX filtered out stops entries that were time points/layovers (either due to it being a known characteristic of the stop, excessive dwell time or having no passenger activity), or for some other reason might have involved the doors being open longer than needed for passenger movement alone.

Table 7. Statistical Analysis of Parking Transaction Times Data

Garage	Sample Date	Sample Size	Average (s)	Standard Deviation (s)	Precision
Central Boulevard Garage	1/15	60	**23.4**	20.4	22%
	2/20	60	**23.9**	13.4	14%
	3/17	60	**22.7**	15.2	17%
	4/14	60	**23.3**	22.1	24%
	5/16	60	**18.8**	7.5	10%
	Combined	**300**	**22.4**	**16.5**	**8%**
Library Garage	1/16	60	**22.1**	8.6	10%
	2/18	60	**25.6**	10.1	10%
	3/20	60	**19.8**	18.2	23%
	4/25	60	**25.9**	17.0	17%
	5/28	62	**25.4**	12.8	13%
	Combined	**302**	**23.8**	**14.0**	**7%**
Market Garage	1/16	60	**24.2**	12.5	13%
	2/20	60	**25.6**	44.9	44%
	3/18	60	**23.4**	10.1	11%
	4/24	60	**24.9**	17.6	18%
	5/14	62	**20.2**	17.2	21%
	Combined	**302**	**23.6**	**23.9**	**11%**
All Garages Combined		***904***	***23.3***	***18.6***	***5%***

- An additional filtering step by the evaluation team removed any remaining stop entries that involved at least 120 seconds per boarding passenger. It was assumed that these represented unrecognized delays beyond what was needed to board passengers (e.g., layovers/layovers). This was a judgment in the sense that all longer durations per passenger (e.g., greater than about 30 seconds per passenger) might be of this type. On the other hand, some of these longer durations could be legitimately associated with a boarding passenger (e.g., trouble finding change or a fare dispute). Implicit in the test hypothesis is the expectation that the smart card would tend to reduce the

incidence of longer fare payment events. So, retaining the somewhat longer duration stop entries in the samples (i.e., the longer ones that are less than 120 seconds) is intended to capture situations that may be mitigated by the smart card.

- The evaluation team noted that some stop entries seem infeasible (e.g., several people boarding within 1-2 seconds). This could indicate a bias in the behavior of the APC equipment (e.g., over counting boardings, undercounting the duration of the door opening). There is no reason to believe that the underlying cause of these is limited only to these stop entries, and these have not been eliminated from the sample to avoid introducing a bias against short duration stop entries. It is assumed that these effects will be prevalent to a similar degree in the before and after testing (i.e., so that they balance out in the before vs. after comparison).
- Passengers simultaneously board (through the front door) and alight (through the rear door). LYNX filtered out stop entries where the number of alighting passengers exceeded the number boarding, in which case the duration of the doors being open would not have been governed by the number of boarding passengers.
- An additional filtering step undertaken by the evaluation team was to remove stop entries listing a dwell time of zero, since these entries apparently represent faulty data.

Table 8 summarizes the sample size, average, standard deviation, and precision percentage for each of these samples. Sample sizes provided by LYNX are substantially different, relative to the time periods covered. LYNX sometimes has dates when some APC data is missing, which accounts for these differences, although these occurrences are random and each sample should still remain representative (i.e., similar averages in the various samples). The confidence intervals on the average for each route are distinct enough that it seems reasonable to not combine the routes together into a single large sample. For these routes, we make the following statistical statements:

- Link 13: At the 95% confidence level, the average transaction time is expected to be 13.0 s +/- 4% (i.e., between 12.5 and 13.5 seconds, 95% of the time).
- Link 15: At the 95% confidence level, the average transaction time is expected to be 10.6 s +/- 3% (i.e., between 10.3 and 10.9 seconds, 95% of the time).

7.2 Quantitative Goal 5 – Increase Prepaid Revenue Share

The agencies wish to (1) reduce cash handling costs and (2) increase the "float" investment revenue earned from holding prepaid revenue. However, changes in cash handling costs and float revenue are not expected due to the limited scale of deployment. Prepaid revenue share was selected as a measurable surrogate quantitative goal for equipped facilities. It is necessary to determine whether some of the ORANGES card usage is displaced from other prepaid payment methods rather than from cash. For this reason, we look at the overall percentage using any prepaid method, rather than only the % using the ORANGES card. This goal has not been applied to tolls for the evaluation, since the percentage paying by transponder will not noticeably increase within the high volume of daily plaza transactions.

Table 8. Statistical Analysis of Transit Transaction Times Data

Bus Route	Sample Date	Sample Size	Average (s)	Standard Deviation (s)	Precision
Link 13	**12/2-12/6**	79	**9.7**	10.4	23%
	12/9-12/13	303	**13.0**	11.2	10%
	1/26-2/1	686	**12.8**	13.7	8%
	4/1-4/14	275	**14.6**	19.1	15%
	6/25-6/30	920	**12.9**	13.3	7%
	Combined	**2263**	**13.0**	**13.9**	**4%**
Link 15	**12/2-12/6**	490	**10.3**	7.4	6%
	12/9-12/13	442	**10.5**	7.6	7%
	1/26-2/1	569	**10.8**	11.6	9%
	4/1-4/14	275	**11.6**	11.2	11%
	6/11-6/17	119	**11.8**	9.2	14%
	6/20-6/30	933	**10.2**	7.5	5%
	Combined	**2828**	**10.6**	**9.0**	**3%**

Measure

- % of transactions that use a prepaid revenue payment method

Test Hypothesis

- % prepaid transactions will increase for equipment accepting the ORANGES card.

Data Collection and Analysis

Parking

The Parking Bureau was able to provide monthly summaries for each parking garage over the period from October 2002 through March 2003, indicating the amounts received for the following types of parking payment methods:

- Monthly parking permits – a prepaid method;
- Transient parking – cash payment at the exit cashier booth;
- Evening parking – cash payment on entry during the evening hours, so that the exit cashier booth can be unattended.

Table 9 presents this data (rounded to the nearest dollar). For each garage, the percent prepaid varies from month to month, so an overall percentage was not calculated for each garage. Instead, a statistical analysis was performed:

- Central Boulevard Garage: At the 95% confidence level, the average prepaid revenue share is expected to be 52% +/- 12% (i.e., between 45% and 58%, 95% of the time).
- Library Garage: At the 95% confidence level, the average prepaid revenue share is expected to be 46% +/- 16% (i.e., between 39% and 53%, 95% of the time).
- Market Garage: At the 95% confidence level, the average prepaid revenue share is expected to be 47% +/- 14% (i.e., between 40% and 54%, 95% of the time).

Table 9. Parking Prepaid Revenue Share Data

Garage	Month	Prepaid	Cash	Total	Prepaid Revenue Share
Central Boulevard	October	$84,863	$51,390	$136,253	**62%**
	November	$69,492	$45,561	$115,053	**60%**
	December	$56,709	$69,174	$125,883	**45%**
	January	$63,953	$59,772	$123,726	**52%**
	February	$57,552	$61,458	$119,010	**48%**
	March	$58,530	$77,712	$136,241	**43%**
Library	October	$43,739	$36,146	$79,885	**55%**
	November	$27,363	$33,567	$60,930	**45%**
	December	$44,029	$40,579	$84,608	**52%**
	January	$42,292	$37,073	$79,364	**53%**
	February	$26,764	$52,989	$79,753	**34%**
	March	$32,961	$58,696	$91,657	**36%**

Garage	Month	Prepaid	Cash	Total	Prepaid Revenue Share
Market	October	$15,228	$24,827	$40,055	**38%**
	November	$19,446	$25,726	$45,172	**43%**
	December	$22,040	$28,643	$50,682	**43%**
	January	$20,776	$26,132	$46,909	**44%**
	February	$6,606	$5,348	$11,953	**55%**
	March	$15,632	$11,075	$26,708	**59%**

Transit

LYNX was able to provide monthly summaries for the fareboxes on each route over the period from November 2002 through March 2003, indicating the percent of the ridership using the following categories of transit payment methods:

- Prepaid – passes, tickets and transfers – and free rides;
- Cash

Table 10 presents this data. This data represents the prepaid share of the ridership, rather than the prepaid share of the revenue (i.e., the prepaid revenue share would be somewhat lower given the lower average fare for prepaid riders). On December 28, 2002, LYNX introduced a new fare structure that replaced calendar weekly period passes with activate-on-first-use 7 day period passes, and added a day pass. As one would expect, these new fare options have shown a tendency to increase the prepaid ridership share. This share was in transition during the before data collection period, so an overall percentage was not calculated for each route. Instead, a statistical analysis was performed for the data beginning from January 2003:

- Link 13: At the 95% confidence level, the average prepaid ridership share is expected to be 58% +/- 3% (i.e., between 57% and 60%, 95% of the time).
- Link 15: At the 95% confidence level, the average prepaid ridership share is expected to be 57% +/- 2% (i.e., between 56% and 58%, 95% of the time).

Table 10. Prepaid Ridership Share Data

Route	Month	Prepaid	Cash	Total	Prepaid Ridership Share
Link 13	November	18,104	18,951	37,055	**49%**
	December	15,680	16,306	31,986	**49%**
	January	20,942	16,020	36,962	**57%**

Route	Month	Prepaid	Cash	Total	Prepaid Ridership Share
	February	21,332	15,449	36,781	**58%**
	March	22,222	14,864	37,086	**60%**
Link 15	November	21,515	23,471	44,986	**48%**
	December	19,853	22,929	42,782	**46%**
	January	26,604	20,321	46,925	**57%**
	February	25,537	19,966	45,503	**56%**
	March	26,433	18,950	45,383	**58%**

7.3 Quantitative Goal 6 – Increase Automated Payment Equipment Uptime

Cash accepting equipment can suffer more downtime as the cash volume increases. This applies more to automated devices than to attended locations, since these devices use mechanical mechanisms to automate cash acceptance. By displacing cash use, the ORANGES card should reduce downtime. This would reduce maintenance costs and revenue loss (i.e., at unattended devices where revenue cannot be collected while the device is down).

Measure

- % operating hours with cash processing available (coins for toll Automatic Coin Machines (ACMs); coins and bills for fareboxes)

Test Hypothesis

- The frequency and severity of planned and unplanned maintenance for unattended devices relates to the amount of cash processed. Cash processing availability should increase as % prepaid increases.

Data Collection and Analysis

Tolls

OOCEA was able to provide data on the times when the various lanes at the Holland East toll plaza were down due to a failure attributed to "Automatic Coin Machines ((ACM) and tunnel vault" (see Table 11). ACM failures are expected to be a frequent occurrence in this category. This data was provided for the entire months from November 2002 through March 2003.

Only lanes 4 and 5 (westbound) and lanes 10 and 11 (eastbound) are equipped with ACMs. The percentage availability calculation is based on the fact that

these four lanes operate continuously. For the purposes of the evaluation, combining the data for the 5-month period enhances the overall value of the percentage availability. The statistical assessment for this 5-month sample indicates:

- At the 95% confidence level, the average ACM % availability is expected to be 99.38% +/- 0.37% (i.e., between 99.02% and 99.74%, 95% of the time).

Table 11. Toll Lanes Automated Coin Machine Uptime Data

Month	Downtime (DD:HH:MM)	Availability
November	00:18:09	**99.4%**
December	00:19:14	**99.4%**
January	00:12:35	**99.6%**
February	01:11:16	**98.7%**
March	00:07:30	**99.8%**
Combined	03:20:44	**99.4%**

Transit

LYNX was able to provide durations for the ten fareboxes that will be equipped for ORANGES acceptance for the entire months beginning November 2002 through March 2003 (see Table 12). The specific cause of the various farebox downtime incidents is not available from this data, although it is known that problems with the cash accepting components are a common cause of farebox incidents.

In this case, combining the data for the 5 months enhances the overall value of the percentage availability. These durations have been combined for the ten fareboxes. The statistical assessment for this 5-month sample indicates:

- At the 95% confidence level, the average farebox % availability is expected to be 99.12% +/- 0.19% (i.e., between 98.93% and 99.31%, 95% of the time).

Table 12. Transit Farebox Uptime Data

Month	Scheduled for Operation (DD:HH:MM)	Operational (DD:HH:MM)	Availability
November	180:10:45	179:7:51	**99.4%**

Month	Scheduled for Operation (DD:HH:MM)	Operational (DD:HH:MM)	Availability
December	186:21:52	185:14:47	**99.3%**
January	185:21:13	183:23:02	**99.0%**
February	168:00:32	166:07:59	**99.0%**
March	186:21:43	184:19:48	**98.9%**
Combined	913:04:05	905:01:27	**99.1%**

7.4 Quantitative Goal 8 – Characterize Current Pass Distribution and Permit Billing Costs

LYNX uses prepaid fares extensively, issuing paper and magnetic stripe passes that are distributed through four sales outlets and by mail order. For the FOT, LYNX passes will be renewed directly on the smart card, at sales outlets or revaluing locations. Sales locations will need fewer paper passes, which should provide savings.

The ORANGES card may also replace the monthly "proximity" permit for garage parking. Currently, permit holders are billed monthly. Although this capability is not included in the initial deployment, a permit could be automatically renewed and the cost billed to a pre-registered credit card.

However, any reduction in the number of passes distributed will be limited during the test (and permits will continue to be billed using conventional methods). Characterizing the current costs for pass distribution and permit billing will indicate the magnitude of the potential cost savings if future deployment achieves bigger reductions. The specific cost categories and assumptions included have been documented for use in any such future consideration of this data.

This goal has not been applied to tolls, which already use a transponder and autoload.

Measure

- Costs for monthly billing of garage permits.
- Costs for distributing conventional weekly and monthly passes.

Data Collection and Analysis

Parking

The Parking Bureau assembled average monthly costs for processing monthly permit invoices. The Parking Bureau included in the cost:

- Salary/benefits cost for the accounting clerk performing this function;
- Postage costs for mailing the invoices.

Table 13 summarizes this data.

Table 13. Parking Permit Invoice Processing Costs

Accounting Clerk Salary/Benefits ($/hour)	$20.19
Average Accounting Clerk Time (Hours/month)	3
Average # Invoices Mailed per Month	335
Postage per Invoice	$0.37
Total Average Invoice Processing Cost ($/month)	$184.52
Average Monthly Cost per 1000 Invoices	**$550.81**

Transit

LYNX assembled monthly costs for processing monthly and weekly passes for the period between November 2002 and March 2003. The average number of passes processed per month was used to calculate the average cost per pass processed. LYNX included in this cost:

- Salary/benefits cost for the customer service staff that sell the passes ($14.24 per hour times a number of hours per month used for pass sales, based on the actual number of passes sold and an assumed average transaction time of 30 seconds per pass sold);
- Cost of the passes themselves (at a cost of $0.11 per pass);
- Salary/benefit cost for the accounting clerks in the money room that process passes for distribution ($17.03 per hour times a number of hours used per month for pass processing); and
- Commissions for pass sales on consignment.

Table 14 summarizes this data. In addition, to presenting the basis for the costs in each reported month, we have also established the results for the entire period combined.

7.5 Quantitative Goal 9 – Characterize Current Processing Cost per Cash Transaction

ORANGES cards should decrease cash processing costs for transit, parking and tolls. However, many types of cash processing savings may not be achieved until card use is more widespread. Thus, the limited use of smart cards in the test may not achieve a significant cost savings in this area.

Table 14. Transit Pass Processing Costs

Month	# of Passes Sold	Cost for Customer Service Staff	Cost for Pass Stock	Cost for Money Room Staff	Cost for Consignment Sales Commissions	Total Cost	Cost per 1000 Passes Sold
November	7,282	$864.13	$793.74	$885,56	$2,087.85	$3,745.72	**$514.38**
December	5,986	$710.34	$652.47	$885.56	$2,105.90	$4,354.27	**$727.41**
January	8,034	$953.37	$875.71	$885.56	$2,890.30	$5,604.94	**$697.65**
February	7,935	$941.62	$864.92	$1,021.80	$2,240.20	$5,068.54	**$638.76**
March	9,064	$1,075.59	$987.98	$1,021.80	$2,195.04	$5,280.41	**$582.57**
Combined	38,301	$4,545.05	$4,174.82	$3,814.72	$11,519.29	$24,053.88	**$628.02**

However, characterizing current cash processing costs will indicate potential cost savings if future deployment achieves bigger reductions in the use of cash. The specific cost categories and assumptions included have been documented for use in any such future consideration of this data.

Measure

- Costs for processing cash, for each mode.

Data Collection and Analysis

Parking

The Parking Bureau assembled costs for the period from October 2002 through March 2003 related to the cash processing costs at each garage. The types of costs the Parking Bureau included were:

- A portion of the salary/benefits cost for the accounting clerk who counts the cash collected from garages, surface lots, and events.

The cash revenue processed during this period was used to calculate the average cost per dollar of cash processed. Table 15 summarizes this data for the

three equipped garages and for all three garages combined, with costs and revenues being the totals for this 6-month period.

Table 15. Parking Garage Cash Processing Costs

Garage	Cash Processed	Cost for Money Counting Staff	Cost per $1000 Processed
Central Boulevard	$366,825	$2,002	**$5.46**
Market	$163,409	$2,002	**$12.25**
Library	$259,050	$2,002	**$7.73**
Combined	$789,284	$6,006	**$7.61**

Transit

LYNX assembled monthly costs for processing cash revenue for the period between November 2002 and March 2003. LYNX included in this cost:

- Salary/benefit cost for the accounting clerks in the money room that process cash revenue from both pass sales and fareboxes ($17.03 per hour times a number of hours used per month for cash processing); and
- Armored car charges to transport the pass sales cash from the sales location and farebox revenue from the garages to the money room location.

Table 16 summarizes this data. In addition, to presenting the basis for the costs in each reported month, we have also established the results for the entire period combined.

Table 16. Transit Pass Processing Costs

Month	Cash Processed	Cost for Money Room Staff	Armored Car Charges	Total Cost	Cost per $1000 Cash Revenue
November	$929,890.90	$10,013.64	$1,966.89	$11,980.53	**$12.88**
December	$892,892.47	$10,013.64	$1,966.89	$11,980.53	**$13.42**
January	$987,955.97	$10,013.64	$1,838.89	$11,852.53	**$12.00**
February	$969,269.47	$9,877.40	$1,838.89	$11,716.29	**$12.09**
March	$936,840.97	$9,877.40	$1,882.96	$11,760.36	**$12.55**
Combined	$4,716,849.78	$49,795.72	$9,494.52	$59,290.24	**$12.57**

Tolls

OOCEA decided not to release cash processing costs data, so this goal could not be evaluated for this agency.

8 Assessment of Current Issues, Risks and Lessons Learned

This section reviews the current status of the ORANGES demonstration, with an emphasis on assessing the current issues, risks to success and lessons learned so far. The minutes from the evaluation conference calls conducted once per month have been included as Appendix B.

8.1 Current Issues

The original premise of the ORANGES demonstration project was that it would demonstrate institutional and technical issues involved in multiple agencies using a single smart card and common stored value purse to pay for transit, tolls and parking in Orlando. As anticipated, several notable issues have emerged so far in the course of the project:

- **Changes in Scope of Deployment:** There have been several changes in the types of smart card use that ORANGES would support:
  - LYNX originally intended that the new GFI Odyssey validating fareboxes being purchased would be equipped to accept the smart card. A dual interface card (with contactless and contact interfaces) was preferred, to allow use with parking meters, parking payment kiosks and certain types of card balance revaluing equipment. However, at that point (in late 2001) GFI was only offering integrated smart card readers for the Odyssey farebox from Sony and Cubic. The proprietary smart cards that work with these readers are not available in dual interface versions. A reader was desired that would use the Type A or Type B contactless interface, for which dual interface smart cards were available. Although the Cubic Tri-Reader can support Type A, Type B and Cubic proprietary card technology, the GFI implementation of this reader on their fare boxes in late 2001 did not yet support the Type A or B cards. Support of the Type A card needed for ORANGES was scheduled to occur, but would not be available to the project until sometime in 2003. This would have caused an implementation delay.

    LYNX was by early 2002 leaning towards adopting the Sony card and reader type offered by GFI and accepting the limitations associated with using a contactless-only smart card. However, the decision to adopt

EFKON equipment for the toll plaza implementation required use of the Mifare contactless interface for compatibility[8]. EFKON was not willing to develop support for the Sony card in their system since it was not being guaranteed a hardware order or being paid for engineering time. A dual interface smart card with a Mifare contactless interface was selected from Gemplus, but an external "stand-alone" smart card reader was needed. Proxibus readers from Ascom were selected for LYNX buses.

One important implication of this stand-alone validator approach was the resulting absence of a driver interface (i.e., validator keypad and display). LYNX chose not to install a driver interface to avoid the driver having an additional interface to that for the farebox. There were some associated limitations in passenger options. For example, (if allowed by the card reader logic) an interface could have allowed the driver to collect the fare for an accompanying person from stored value on the same card after a passenger pays for their fare with their pass.

- OOCEA was initially reluctant to integrate smart card accepting transponders or laneside smart card readers with its existing transponder-based toll collection system. There was a concern with integration costs and possible temporary disruptions to the operation of the existing system during integration. There was also an initial reluctance to equip the system with laneside smart card readers, based on an underlying concern about whether this might negatively affect transponder market penetration.

  In early 2002, EFKON was selected to provide a system for smart card accepting transponders that would operate in a manner almost entirely independent from the existing toll system. These transponders and readers use infrared technology for short-range communications. The integration was limited to a signal from the EFKON equipment to activate the laneside displays (traffic lights) that tell drivers when the toll has been collected and they can drive through. In October 2002, OOCEA decided to incorporate the EFKON "Touch'N'Go" laneside readers in selected lanes..

- The City of Orlando Parking Bureau initially planned to accept the smart card at garage entrance and exit lanes, parking meters and parking payment kiosks. A decision was made in 2001 not to incorporate smart card readers into parking kiosks. A decision was made in late 2002 not to

[8] Mifare is a variant on the Type A interface, available from several card manufacturers.

incorporate smart card acceptance at the parking meters. These decisions were made due to a lack of funding for software development, and the delays that this additional software development would have required, and affected the number of parking participants in the study.

- **Limited Scale of Deployment:** The implementing agencies took into account the cost and the time available for implementation when establishing the scale of deployment (i.e., the routes and locations at which to deploy smart card accepting equipment). The implementing agencies also indicated that risk management was taken into account at certain decision points. One example was in considering the potential expense of the escalating integration issues that are often prevalent when fully integrating with legacy systems using a limited budget. Another example was selecting payment applications that took existing patents (e.g., the process patent for the use of transponders to pay for parking) into account. The opportunity was taken to seek out private sector partners that were motivated to offer volunteer services and equipment, to maximize the scale of deployment given the limited budget.

  The decision to avoid toll system integration was one factor that led to selecting EFKON equipment. EFKON supplied the equipment necessary to equip the busiest toll plaza in the OOCEA system, as requested by the ORANGES partnership. The partnership agreed to include EFKON in its outreach efforts, detailing the services and equipment supplied during the project.

  The quantity of equipment supplied by ASCOM met the request from the ORANGES partners for outfitting the link 101-bus route and the LASER (University of Central Florida circulator route) on the LYNX system. Both routes were discontinued during the course of the project. Two other bus routes were selected (link 13 & link 15) in place of the link 101. Limiting where the smart card would be accepted impacted the potential pool of cardholders. For example, LYNX pass users that typically use non-equipped routes would be less likely to be interested in the smart card (since a pass on the smart card would not be useable on these routes).

- **Limited Number of Cardholders:** The implementing agencies initially intended to issue 150-500 smart cards. This was considered by the evaluation team to represent a very low number of cardholders for useful results. There was also a concern that some issued cards might not remain in regular use throughout the demonstration period. As a result, the implementing agencies agreed that 800-1200 active cards would need to be

in use throughout the 12-month evaluation period (i.e., issuing additional cards if some become inactive). It was agreed that a card would be considered inactive if it had not been used at least once within three consecutive weeks.

- **Duration of Implementation Period:** As was discussed earlier, the overall implementation period (from the start of development through to ORANGES cards being used by actual cardholders in revenue service) took longer than the implementation team had originally planned. The plan was for it to take 11 months to develop an integrated demonstration system in an office environment, followed by a 13-month period until the fully deployed revenue service demonstration system would be in place. This 13-month period was itself intended to be staged. A limited scale version of the field deployment was going to be put in place over a 7-month period, followed by an expansion of the field deployment system to the full scale of the demonstration over the remaining 6 months of the rollout period.

  The overall deployment period thus increased from a planned 23 months to 26 months. This was due in part to increased time for the initial systems integration stage, which appears to have involved several factors:

  - As discussed earlier, several complications and reassessments arose as the implementation team selected the appropriate smart card, readers and equipment retrofits to install.
  - Vendor Agreements: Agreements enabling use of the Ascom and EFKON equipment were not executed until June 2002, 14 months after the start of the FOT development.
  - Equipment Selection/Additional Toll Component: Discussion about the specific nature of the parking field equipment (and the addition of the laneside readers to the toll plaza component) was not resolved with suppliers until October 2002.
  - LYNX Service Changes: An additional delay arose in late 2002, due to changes in LYNX operational funding at the end of 2002 that cancelled the routes that had been intended for use in the trial. Alternative routes had to be selected that could use a similar number of the Ascom validators, since this quantity had already been agreed.
  - Supplier Production Delays: In July/August 2003, there were delays in receiving the smart card shipment, which delayed the initial enrollment

of cardholders and card distribution even though the cardholders had already been recruited.

  - Software/Systems Integration: There were systems integration delays for a variety of reasons, including limits on the availability of staffing resources. The decision to use some demonstration equipment provided by the vendor at no cost appears to have increased the complexity and time required for the integration effort. Although the vendor provided the equipment and in some cases its associated software, they did not provide all of the software customization and integration support services that they would provide under normal circumstances. This increased the effort and complexity for the systems integrator. These additional requirements exacerbated the system integration delays.

- **Deferred System Functionality:** The deployment system was launched in August 2003 without the implementation of the EFKON smart card enabled transponder. The central clearinghouse system for the deployment processes the various payments and revaluing transactions retrieved from field equipment to enable appropriate funds transfers between participant accounts, rather than maintaining centralized account balances. Centralized account balances are needed for smart card accepting transponders. The systems integrator needed additional time to support this functionality. The implementing agencies decided to launch the FOT without the smart card accepting transponders, rather than defer the remainder of the system. The project team had indicated that this capability would be in place by the end of September 2003, but as of November 2003 it is not yet implemented.

- **Limited Initial Card Activity:** Although the agencies used a pre-screening method to select cardholders, with each offering an incentive (either to initially try out the card or on an ongoing basis), the initial experience with cardholder transaction activity has been discouraging. The initial group of cardholders was recruited in May and June of 2003 with an anticipated launch date of July 2003. System integration and smart card delivery delays resulted in cardholders not receiving their smart cards until the third week in August. The delay between recruiting and actual implementation appears to one factor that has had an adverse affect on participation. Recruiting recommenced in November 2003, it is hoped that participation will be higher now that the system is in the field. For the week ending November 9, 2003, TTI reports that 771 cards had been issued but only 12% were active[9].

[9] A card is being defined as active once it is first used in a payment or revaluing transaction. A card is being defined as inactive once it has not been used for any transactions in three consecutive weeks.

The number of active cards is currently well below the requirement to maintain 800-1200 active cards throughout the trial. The selection of 30-50 cardholders has been deferred until the smart card accepting transponders functionality is operational (i.e., these cardholders would also be issued with a smart card accepting transponder).

- **Discontinued Smart Card:** In September 2003, Gemplus informed the implementing agencies (with no prior warning) that the GemCombi dual interface smart card originally purchased has now been discontinued and is no longer in production. The replacement dual interface card from Gemplus is to be based on the Java operating system and be "backwards" compatible with the existing readers. However, these cards are not expected to be available until 2005. The original inventory was 2100 cards, so there are still additional cards that could be distributed. Another option (with cost and time effects) would be to modify the system to accept a different card.

8.2 Risks to FOT Success and Mitigation Strategies

The following discusses certain risks for the success of the FOT that can be discerned at this point, and some possible mitigation strategies:

- **Limited Scale of Deployment Could Make Interpretation of Evaluation Results Challenging:** For various reasons, the implementation team has only deployed smart card acceptance to a limited extent with each agency. As a result, there is some risk that it will be difficult to draw conclusions about the test hypothesis when looking at the effect on the measure in the before/after testing. For example, with only a limited number of boarding passengers using the smart card on the equipped LYNX routes, as a proportion of the overall boarding volume, it is likely that only a limited effect on the average transaction time measure may be observed. This issue/risk was identified early in the evaluation strategy as an effect of the limited scale of deployment.

  Assuming that the scale of the deployment will not be increased, there is no straightforward mitigation strategy. The lack of a demonstrated success against an evaluation goal/measure does not inherently imply failure.

- **Limited Card Activity:** The initial transaction activity experience indicates that over half of the recruited cardholders have not used their card in the past three weeks with any mode, within about 2 months of the start of the trial. There is a risk that additional cardholders could become inactive.

It is suggested that the implementing agencies contact cardholders that have become inactive to discuss any concerns they might have about the system. In particular, LYNX has noted that University of Central Florida and Valencia Community College were not is session during the initial recruitment. Since these students are some of the primary users of the equipped routes, a secondary recruitment drive could be useful.

- **Smart Card Supply:** Given the current active cards rate (roughly 10%), the current inventory of 2100 cards would not be sufficient to achieve the required 800-1000 active cards. As a result, the 12-month demonstration period will inevitably have a degree of attrition. Additional compatible cards may not be available from Gemplus until 2005, which could prove to be a critical factor.

  The agencies should consider retrieving inactive cards from cardholders if possible and redistributing the cards to new participants. The alternative or complementary strategy would be to increase the active cards rate, by providing additional outreach and incentives to motivate cardholders to use the card.

8.3 Lessons Learned

The following discusses some of the lessons learned from the experience to date with the implementation of this FOT:

- **Systems Integration:**

  Do not underestimate the complexity of integration and interoperability issues: The implementation team required considerably longer to complete the design phase of the system than they originally expected. This involved determining the correct combination of smart card, readers and retrofitting of various types of existing field equipment. The primary complicating factor was that the vendors were only willing to provide a limited amount of support without being paid for their efforts. This issue could be addressed more easily with documented requirements for the system prior to vendor selection

- **Recruitment:**

  Extra effort in initial cardholder recruitment screening and education could pay dividends: The limited number of cards being issued made it essential for cardholders to be properly screened. The usage patterns of potential recruits were screened by agency customer

service representatives and via the project web-site to attempt to recruit cardholders that use the actual routes and locations accepting the cards. Flyers were also handed out at the specific toll plaza and parking garages where the cards were to be accepted. LYNX recruiting was completed on-board buses and at bus stops (for Link 13 & Link 15) by a professional recruiting firm.

Some of the initially recruited cardholders are not using their card at all, using it for a brief time then stopping, or using it sporadically. It is possible that some adjustments to the recruitment approach could have helped in identifying cardholders that would be likely to use the card. Insight into this might be gained through followup with cardholders.

It is also possible that some cardholders have found some strange or uncomfortable things in using the system, which are getting in the way of their using it. It is also possible that the limited number of card acceptance locations is a disincentive toward continuous use. In any case, additional education/outreach for cardholders at the outset and from time to time during the FOT could have a very positive impact (in helping cardholders feel more comfortable in using the system and/or improving the system in some way).

- **Equipment Inventory and Suppliers:**

  Be conservative in the number of smart cards ordered: Smart card systems can substitute a new smart card from the card originally selected, although this will incur additional costs to allow the readers to accept the new cards. Yet, as Gemplus has shown, card products with limited market share can be discontinued before the replacement product is available (or conceivably without offering a replacement at all) and with little warning to current customers. By ordering only 2100 cards from Gemplus when there was a mandatory requirement for maintaining 800-1000 active cards throughout the 12-month demonstration period, the implementation team was inherently assuming that if there was a lower than expected active card rate or higher than expected cardholder attrition, they would be able fall back on ordering additional cards.

- **Developing Effective Cost Strategies:**

  There are tradeoffs to using reduced cost equipment in a demonstration project: The implementation team made several arrangements with vendors, to supply equipment at a reduced price in consideration of the relatively high profile that involvement would

provide. Some vendors were interested in the opportunity to offer lower cost equipment, but offered only limited quantities. In addition, software customization and systems integration support services that would typically be offered by the equipment vendor became the responsibility of the overall systems integrator.

The implementing agencies indicate that this approach was based on a risk management decision that took into account the odds for success and cost estimates received for integration with existing systems. They estimate that half of the federal funding provided for the project might have been expended for this part of the overall integration effort alone. The implementation team identified these equipment arrangements with vendors as a viable solution to achieve implementation given the available funding, once it was clear that initial attempts had proved unacceptable from a risk management perspective. This approach limited the need to use capital project funding for these equipment purchases. The conservative scale of deployment also helped reserve sufficient funding to last throughout the duration of the field operational test.

9 Conclusion

Phase I of this evaluation has developed a comprehensive set of goals based on a consensus building process with the implementing agencies, as well as feasible and practical measures and data collection methods. These data collection measures have now been used to establish a solid base of quantitative and qualitative before data. Completing the after data collection will provide some of the first quantitative data on the types of benefits expected from multimodal electronic payment systems. In addition, the before and after cardholder and employee discussion groups will provide critical insights into how perceptions about key issues are affected by the experience of using such a system.

Based on insights from examining the system implementation period, several important issues, risks, mitigation strategies and lessons learned have been documented.